Environmental Studies Program: Ongoing Study

Title	Measuring Wave Forces along Alaska's Coastal Sea Ice (AK-13-03-17)
Administered by	Alaska Regional Office
BOEM Contact(s)	Dr. Heather Crowley, heather.crowley@boem.gov
Conducting Organizations(s)	CMI, UAF
Total BOEM Cost	$311,392 plus Joint Funding ($311,392)
Performance Period	FY 2016–2021
Final Report Due	March 2021
Date Revised	August 9, 2021
PICOC Summary	
Problem	Landfast ice is used as a platform for subsistence hunting and potentially for wintertime activities related to oil and gas exploration and development in the Beaufort Sea and Chukchi Sea. To ensure the safe use of landfast ice as a platform, BOEM needs a better understanding of the mechanical properties of sea ice within the landsfast ice zone and the stresses that cause breakout events.
Intervention	This project will design, fabricate, and field test portable sensors that measure the 3D acceleration of the landfast ice to measure acceleration of the landfast ice and estimate the stresses imparted into the ice.
Comparison	The study will evaluate the relationship between variations in infragravity waves in the landfast and ice destabilization events.
Outcome	The development of portable sensors of ice movement that can be monitored in real-time could allow for prediction of landfast ice breakout events, leading to early warnings and improved ice safety.
Context	Beaufort Sea, Chukchi Sea

BOEM Information Need(s): This study will provide a better understanding of the stresses that cause breakout events associated with landfast ice along the Chukchi and Beaufort coasts from wind, waves, coastal waves, and storm surges. The results from the sensor measurements will be used to better understand the mechanical properties of sea ice within the landsfast ice zone. Information will provide supporting data to improve our understanding of ice safety and marine navigation during the spring months. Information could also be utilized in NEPA documents to assess the risk of landfast ice to proposed exploration and production activities.

Background: Landfast ice stability is extremely important to the Alaska Native subsistence hunters along the Chukchi coast. During the spring hunt for bowhead whales the subsistence hunters use landfast ice as a stable hunting platform. Breakout events occur when there is a sudden detachment of the landfast ice platform from the coast. In some years, large breakout events have stranded subsistence hunters offshore on drifting sea ice. Climate change may cause earlier and more frequent breakout events due to longer periods of open water causing greater exposure of the ice edge to the

forces of waves and storm surges. A set of inertial motion units (IMUs) sensors will be designed and deployed to measure ice acceleration due to waves propagating through the landfast ice off Barrow, Alaska. These types of measurements will improve ice safety by understanding how propagating waves impacts landfast ice stability and fragmentation along the coast. These measurements will also help to achieve a better understanding on the processes associated with larger breakout events that occur on an annual basis along the Chukchi coast. The experiment of measuring wave propagation into the landfast ice has been tested in Norway with success. This study plans to reproduce a similar experiment along the coast of the Chukchi Sea to measure those wave forces in the landfast ice near Barrow, Alaska.

Objectives: The overall goal of this project is to improve ice safety by understanding wave energy propagation into sea ice, and determine its effect on landfast ice stability along the Chukchi coast. Specific objectives include:

- Improving the ability to detect infragravity waves at the fast ice edge and directly measure ice acceleration, wave period and arrival time.
- Developing estimates of wave velocity and amplitude and propagation direction.
- Gaining a better understanding of wave origin, propagation path and attenuation and their relationship to the mechanical properties of ice.
- Estimating the stresses imparted into landfast ice.
- Evaluating the relationship between infragravity waves and landfast ice destabilization events.
- Assessing the effect of ice topography and heterogeneity of wave propagation.

Methods: This project will design, fabricate, and field test portable sensors that measure the 3D acceleration of the landfast ice. Year one field testing will be conducted in Fairbanks, Alaska. During year two, the researchers will build three IMU wave sensors for full deployment during the spring months on the landfast ice edge off of Barrow, Alaska. In year three, the IMU wave sensors will be deployed away from the landfast ice edge to test the feasibility of measuring wave attenuation and estimate along path ice thickness. In year four, researchers will continue development of wave sensor capability and deploy IMU wave sensors on the landfast ice off Utqiaġvik, Alaska. Local residents will be involved in the sensor deployment and conducting outreach activities as practicable.

Specific Research Question(s):

1. How is energy from wind, waves, coastal waves, and storm surges transmitted through landfast ice?
2. How do variations in these factors impact landfast ice breakout events?
3. Can breakout events be predicted through measurements of infragravity waves in landfast ice?

Current Status: Completed

Publications Completed:

Johnson MA, Marchenko AV, Dammann DO, Mahoney AR. 2021. Observing Wind-Forced Flexural-Gravity Waves in the Beaufort Sea and Their Relationship to Sea Ice Mechanics. J. Mar. Sci. Eng. 9, 471. https://doi.org/10.3390/jmse9050471

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